

LIBRARY OF CONGRESS.

Chap. TC 225

Shelf B7

1863a

UNITED STATES OF AMERICA.

*Gen. Samuel Hooper
with respects of
the Author*

BOSTON HARBOR:

A SERIES OF COMMUNICATIONS

TO THE

BOSTON DAILY ADVERTISER,

BY

BENJAMIN A. GOULD,

REPUBLISHED BY ORDER OF THE CITY COUNCIL OF BOSTON.



BOSTON:

J. E. FARWELL & COMPANY, PRINTERS TO THE CITY,

37 CONGRESS STREET.

1863.

BOSTON HARBOR:

A SERIES OF COMMUNICATIONS

TO THE

BOSTON DAILY ADVERTISER,

BY

BENJAMIN A. GOULD,

REPUBLISHED BY ORDER OF THE CITY COUNCIL OF BOSTON.

15.15.6
4451



BOSTON:

J. E. FARWELL & COMPANY, PRINTERS TO THE CITY,

37 CONGRESS STREET.

1863.

IC 225
BT
1863a

6-12998

CITY OF BOSTON.

In Board of Aldermen, December 7, 1863.

ORDERED: That the Committee on Printing be authorized to have printed, with the permission of the author, for the use of the City Council, five hundred copies of the articles on "Boston Harbor," recently published in the "Daily Advertiser."

Sent down for concurrence.

THOMAS C. AMORY, JR., *Chairman.*

In Common Council, December 10, 1863.

Concurred.

GEORGE S. HALE, *President.*

Approved, December 12, 1863.

F. W. LINCOLN, JR., *Mayor.*

COMMUNICATIONS.

NUMBER I.

UNDER the title of "Communications and Reports in Relation to the Surveys of Boston Harbor," the series of Reports of the present Harbor Commission have recently been bound up together and issued in a neat volume by the City Government, together with impressions of as many of the maps and tracings as are requisite for a general understanding of the subject.

Although of course every Bostonian is interested in the preservation of the once admirable Harbor to which all the prosperity of our City is due, and though the importance and wealth derived from its commerce has in fact been one of the principal sources of the intellectual pre-eminence of New England; yet, only those few who have given careful study to the subject seem to be at all aware of the alarming deterioration which it has suffered in recent years.

Not only have the Islands, once so beautiful, — the

protection of the roadsteads and the guards of the channels, — been destroyed to a startling extent by the action of winds and waves for want of the artificial protections which became a necessity, at least for their headlands, after the original safeguards of ballast-shingle, trees, and grass had been removed; not merely, in addition, have the channels filled up, the flats extended and shallowed, new shoals formed and old shoals grown larger, but the hand of man has recklessly destroyed natural agencies on which the harbor depended for protection, and has called into action other influences detrimental to an extraordinary degree.

It was doubtless by the discovery or keenly awakened sense of the danger which actually threatened annihilation to the commercial prominence of our City, — already waning, and indeed undeniably diminished relatively to other seaports of the Northeast, — that our excellent Mayor, during a former term of office, took those steps which led, through his continued exertions, to the appointment of the present Harbor Commission. In a message to the City Council, in 1859, he called their attention earnestly to the subject, and urged the appointment of a Scientific Commission to investigate the changes in the harbor. We will quote from his communication of October 24: —

“The prosperity of our city is intimately connected with its foreign and coastwise commerce. Its situation on the Atlantic seaboard, having one of the best harbors in the world, has given it its rank as one of the most important maritime ports of modern times. Anything which endangers the safety of its harbor, caused either by the hand of man or the ravages of the sea, should be watched with jealous scrutiny and care.

“Its local importance to ourselves as well as to the Commonwealth, of which we are the capital, cannot be over-estimated, but it has a national importance equally significant, for within its waters is established one of the best of the naval stations of the Union, and through its Custom House a large portion of the Revenues for the support of Government are collected. Boston Harbor does not belong to Boston alone, but to the whole Nation; and we are recreant to duty if, living in the immediate vicinity, we do not adopt all those instrumentalities which shall secure its safety.”

.

“Recent investigations have shown that the time is come for some energetic measures, which shall embrace the lower, as well as the upper harbor. In the former, islands and headlands are washing away, the ship-channel is becoming narrow, and symptoms are every day developing, the results of which will be disastrous if not speedily checked and abated.

“The National Government has done much, by the strength and character of its fortifications, to assure our safety from the attack of the foreign fleets of an enemy; but their atten-

tion should now be solicited to those insidious assaults of the sea, which are constantly undermining and putting in jeopardy the integrity of our harbor. Through the exertions of one of our late representatives in Congress, Mr. Comins, a bill was reported at the last session from the Committee on Commerce, making an appropriation for a scientific survey. The bill failed to pass the House,—not so much, I understand, from an indisposition to aid the matter, as from a want of knowledge of the facts which would justify such an appropriation. In this dilemma, following the example of other cities, I would suggest for your consideration the appointment of a Commission for the examination of the subject. These Commissioners should be of high scientific attainment, of much experience in the examination of tidal waters and oceanic currents, free from any local bias, and whose testimony would be of weight in the Congress of the United States. Some tangible facts from a source which cannot be questioned, must have an influence upon that body.”

Fortunate enough was it for Boston that, even at that time, the interest of the official fathers was invoked. A very few years more and it would have been too late. Not Mayor Lincoln, not the merchants, not even the pilots, were fully aware of the extent of the deterioration of the harbor, nor of the alarming and actually increasing rate at which it was going on.

The “Joint Standing Committee on the Harbor”

—for such a Committee of the City Council had long existed—reported without delay, cordially approving the recommendations of the Mayor, and proposing the necessary legislation. Orders were passed at once authorizing the Mayor to invite General Totten, Professor Bache, and Commander Davis, to act as Commissioners to investigate and report upon the condition of the harbor, with a view to its preservation and safety; and furthermore, the consent of these gentlemen being obtained, to solicit the executive departments at Washington to detail them—all being officers in the United States service—for this special service. The necessary official action at Washington was obtained through the personal exertions of Mayor Lincoln; and since November, 1859, the three gentlemen already named have gratuitously served as a Harbor Commission for the City of Boston. They have already planned, organized, and superintended three distinct surveys, executed by the assistance of the Coast Survey and its officers; and have presented six important and elaborate reports, beside sundry minor communications. If their warnings are but heeded, and those counsels which are the abundant fruit of their labors can be permitted to ripen into practical action, unborn generations may be grateful that Boston remains a centre for commerce, science, letters, and art.

The earliest full report of the Commissioners was in March, 1860. It stated that the City Government had in no degree over-estimated the serious and injurious changes which were going on in the harbor; that the encroachments of the sea were destroying the headlands and islands; that channels had grown dangerous to vessels of deep draught, having become narrower in some places, and the deep water being so much encroached upon, that where the pilot-boats were not long since accustomed to run boldly up to a steep shore, to land their crews or to lie to during a gale, shoal ground now precluded their approach. Also, that the navigable part of the inner harbor had lost in area, the width of the channel become less, and its direction altered.

They presented, without formal recommendation, though with sufficient distinctness to indicate their opinion of the importance of the respective examinations, estimates of the cost of a new hydrographic survey of the main ship-channel, of a topographical survey of the shores and islands of the lower harbor, and of a series of gauges and current observations, in the Charles, Mystic, and Neponset rivers. And they added two distinct recommendations: —

In the first place, that prompt and effectual measures be taken to prevent the removal of any more material from Gallop's, and the other islands of the

harbor; and that the former be taken out of private hands, if possible, and put into public keeping.

In the second place, that the existing water area be preserved until some plans and some principles should be recognized and adopted by which private interests may be subserved without the sacrifice of the public good.

These recommendations were complied with. The title to Gallop's Island was promptly and judiciously secured by the City, and a temporary check was placed upon the numberless encroachments which were so rapidly sacrificing the permanent prosperity of the City to the temporary aggrandizement of reckless individuals.

During the summer of 1860, maps were constructed for exhibiting the changes which had occurred in the inner harbor. The results of the examination were such as to lead to a special communication from the Commission to the City Government on the 2d of November. They announced that the changes had proved to be of a striking and even alarming nature; that they regarded it as of the highest importance that a new and very minute survey of the inner harbor should be made, — covering the same ground as that of the survey in 1835-6, — and strongly urged this upon the City. The Municipal Government responded at once, the

Committee on the Harbor earnestly advocating the survey, and the City Council, by a unanimous vote in each branch, requested the Commissioners to make the survey suggested, and appropriated eight thousand dollars for the purpose. This survey is now mostly completed.

There are thus available at present for the detection of the changes, the study of their laws, and the discovery of their causes,—

1. The survey of the inner harbor by the first Commission, which was appointed by the State, in 1835, and consisted of Messrs. Baldwin, Thayer, and Hayward.

2. The survey of the entire harbor, executed in regular course, by the United States Coast Survey, in 1847.

3. The hydrographic survey of the main ship-channel, in 1860.

4. The topographical survey, in 1860, of the shores and islands of the lower harbor north of $42^{\circ} 18'$.

5. The series of river gauges and current observations executed, on an extended scale, during 1860 and 1861.

6. The minute survey of the inner harbor, by the present Commission, begun in 1860, and now essentially completed.

From these materials the desired information may be deduced without much difficulty.

And although the injuries inflicted upon the harbor by the hand of man, during the last fifteen years, are beyond the power of man to repair; although we cannot reasonably hope that the harbor will ever be restored to the excellent condition in which it was delivered over by the last generation to the present, it is perhaps not too late to remedy some of the injury, and it is certainly within our power to arrest the progress of encroachment.

NUMBER II.

We have recently given an historical summary of the circumstances connected with the appointment of the Boston Harbor Commission, and a brief statement of the character of their labors hitherto, so far as we have seen the published results. They have reported, among other things, —

That the headlands of the harbor are rapidly washing away in many places.

That new spits, or submerged points of land and new shoals are forming, and in dangerous positions.

That the channels are losing in width, in depth, and, in some places, in directness.

That the flats are in many places rising, and in general extending, so that the navigable area of the inner harbor is essentially diminished.

That these changes are of a magnitude already quite detrimental to navigation, and that the agencies which produced them are still actively at work, and in some cases with increased activity.

Such a state of things may well arouse the most phlegmatic, exciting the apprehensions and demand-

ing the exertions of every true Bostonian. Can we not act speedily and vigorously? How shall we act? And how combine our individual efforts to remedy whatever is not past remedy, and to mitigate whatever cannot be entirely obviated?

With a view to answering these and similar questions, we have carefully and earnestly studied the reports of the Harbor Commission. And it would seem as though the simplicity of the laws which regulate and control the changes were such that none could fail to comprehend them; notwithstanding the obvious fact that here—as in all other cases where simple laws are acting simultaneously under different circumstances—a complication must result, which those unacquainted with the subject are too apt to refer to some complexity in the laws, rather than to its true origin in the variety and diversity of the circumstances under which they find application.

Let us consider for a moment what are the chief influences which may act upon a harbor for good or ill, and then it will doubtless be comparatively easy for us, who know the local relations, and are now provided with the fundamental facts, to reduce our special inquiry within tolerably narrow limits; even though we should not be able to attain to a distinct and complete answer.

It is self-evident that a permanent harbor or chan-

nel cannot exist, except where either no constant injurious influences are at work, or where such influences are balanced and entirely defeated by other agencies of a beneficial character; and furthermore, that any such balance of influences must be essentially a state of stable equilibrium, else in the course of years it would have been long since overthrown. Harbor changes may thus be reasonably attributed in every case either, in the first place, to some general influence affecting the entire region, such as the elevation or subsidence of a coast, — to the progress of some regular deposit or detrition reaching a limit toward which it had long been tending, and its effect upon which might for a long time previous have been foreseen; or, in the second place, to some special influence which is in most cases attributable to human agency, — although sometimes due to earthquakes, volcanic eruptions, or some other sudden natural calamities.

But where, as in our own case, the natural adjustment has been evidently disturbed, and that equipoise of natural influences which, in past ages, constructed and has since maintained Boston Harbor, has been overthrown, we must look to some comparatively recent influence to explain any recent change. This is certain.

Now what makes a channel? A running stream

which has sufficient power to form for itself a bed ; or, in other words, which can exert scouring force adequate to the displacement and removal of some of the materials over which it flows. If this material be sandy gravel, a velocity equivalent to its half-a-mile an hour is found, by experiment, to be requisite for such displacement; if fine beach sand, three tenths of one mile an hour will suffice, — and the needed velocity is, of course, less for simple mud and greater for coarse stones. And a stream the force of whose current is ever sufficient to bring about this scouring velocity at the bottom will wear for itself a channel, even though its bed be dry for eleven months out of the twelve. The same principle applies moreover when, as in the case of harbor channels, the bed is never dry, or even visible ; and it is clear that, if a stream meets the tide with the bottom velocity of only one tenth of a mile an hour over a gravelly bed, this will be sufficient to scour out for itself a channel, provided the ordinary tidal flow can supply the remaining four tenths of a mile an hour. For, even were the tidal flow one half a mile an hour at the bottom, its inward force would be decreased by the outflow of the stream to a velocity of four tenths, which could transport none of the material up stream ; while the force at ebb, composed of the tide-flow and the river current combined, would be equal to an

hourly rate of six tenths of a mile, — and thus move the material of the bottom seaward twice a day. In this way a channel necessarily results wherever a stream has sufficient force for the average velocity of outflow at the bottom, when combined with the tidal current, to remove the material of the bed, either by rolling or by washing away. No matter how great the tidal force, or how great the semi-diurnal motion of the materials of the channel-bed inwards; if any river current whatever exist, the semi-diurnal outward motion will be greater yet, and a channel will be the inevitable result. So too if by reason of the conformation of the shore, the outward tidal current at all exceed the inward in velocity at the bottom, the same result ensues, provided only that the outflow be competent to the removal of the material at all.

Again, if a current, bearing with it rolling gravel and sand, be — by reason of any sudden expansion of the channel through which a given amount of water is discharged in a given time — reduced to a velocity below the scouring limit, the material is deposited at that point where the scouring velocity ceases to exist. If, however, the material moved by the current be finer and lighter, so that it is in any degree held in suspension, the loss of scouring velocity does not necessarily require that the deposit be immediate; but the material mostly remains in suspension, set-

ling slowly to the bottom as the current flows on, and being chiefly deposited where the current ceases. In this way bars or shoals are formed at those places, near the mouths of streams, where the outward flow is suddenly provided with increased facilities for its discharge, occasioning diminution of velocity; or where in consequence of conflicting currents slack water occurs, either permanently or at regular tidal intervals.

These considerations suffice to show the importance of maintaining river currents, no matter how small, and tidal reservoirs, so called, — provided those channels, which have been occasioned by their outflow, need to be maintained. The agencies of nature are always active, — if not for us, they are against us; and the equilibrium of nature is never one of stagnation, but arises always from an equipoise of motion and force, — either active or ready to become so. No channel will remain a channel if the producing forces cease to be maintaining forces. If there be no scour of the bed, there will be a deposit. The channel will either be maintained, or will begin to be obliterated.

If a tidal current, of any degree of strength above the scouring limit, set alternately as the tide ebbs and flows, the material of the channel-bed will be swept inward with the flood and outward with the ebb. And it is manifest that where the amount of inward and outward transportation of the material is equal,

no permanent change of the channel can be brought about; but that if either predominate, as is the case when the duration of ebb and flow are unequal, or when the conformation of the shore gives them unequal force, a change, either for good or ill, must necessarily take place. One more element must however not be overlooked; viz: the different character of different tides. For no estimate of the permanent effect of tidal action will be accurate which is founded on consideration of the average tides only, omitting that of spring-tides and freshets. The effect of the latter is almost uniformly favorable to the maintenance of channels; for the increased volume of water at the flood fails by reason of its depth to exert on the channel-bed any inward scour at all commensurate with the outward one, which is produced by the current at the very low water of the corresponding ebb.

The principles thus laid down—rather broadly it is true, lest, in an attempt to express ourselves with strict scientific precision, the clearness of explanation be too much sacrificed—are entirely adequate to the explanation of a large part of the phenomena observed in Boston Harbor. When taken in connection with the contour of the shore at different stages of the tides, and with the form of the bottom, they will answer the most important of the inquiries relative to its impending destruction. They may be essentially summed up as follows:—

The preservation of a channel must depend upon the constant, or at least continually recurring action of a maintaining force. This maintaining force must arise from a friction of the water in contact with the bed, sufficient to wear or roll away part of the material of which the bed is composed, or such matter as may be deposited there; and furthermore if, as in the case of tidal channels, the motion be in different directions at different times, the motion in one of these directions must sufficiently predominate to prevent the material which is removed at one time from being restored to its original position when the current is reversed. That the channel may be a continuous and useful one, the predominant motion must be outwardly, and the desired effect may be secured in three principal ways.

1. By the outflow of a river, or even a stream too small to deserve that name, yet competent to give the needed predominance of outward motion, — especially at the lowest ebb, or where the unassisted tidal current approaches without usually attaining the force requisite for producing a scour.

2. By the outflow of “tidal reservoirs,” which receive, during the rise of the tides, a volume of water to be discharged along the channel with greater effect on the bottom when the tide is low. Meadows and lowlands, which are overflowed during extraordinarily

high tides, often contribute no unimportant aid in this way.

3. By a contour of the shore line or even of the bottom, which leads the outflowing current along a different path from the inflowing one, or else confines the outflow within narrow limits, — thus giving to the same volume of water a greater velocity.

If on the other hand two currents, each of which exerts a scouring force on its own channel, meet at a sufficient angle to bring the momentum of their current after confluence below the limit required for carrying away all the material which they bring with them to the place of meeting, — a shoal or bar is inevitable. This is true, whether the currents be those of rivers, or the outflow of basins, or are due to the semi-diurnal fluctuations of the tide. And wherever at any time of tide or in any part of a stream, slack water occurs, or the water remains for a time in a state of comparative repose, we must expect a deposition as sediment, of the material previously held in suspension. But spring-tides and freshets are competent to remedy much of the difficulty thus arising, and by their influence many a channel is kept open from year to year, which is, during a great part of the time, subjected to detrimental influences.

NUMBER III.

In our last communication we endeavored to state, in as brief compass as was compatible with distinctness, the general laws which control the formation, destruction, or maintenance of harbor and river channels. Let us now inquire what constitutes a good harbor, or rather what are the principal requisites for giving maritime value to a port. We say maritime value, because we are considering the question solely from the nautical side, without regard to those other requirements which affect its commercial importance, and the absence of which leaves some of the finest harbors in the world unfrequented.

The sailor will tell us that he requires an easy access. The channel must not be tortuous, nor frequently shifting; the main approaches must be deep enough to float full-laden ships at the lowest stage of tide, and wide enough to be safe with ordinary care. Besides this he would ask for one or more good roadsteads, where his vessel may safely ride at anchor during heavy blows from any quarter, especially from seaward; in short, for room, anchorage, and shelter.

That the port should be accessible during any wind is also most desirable, though perhaps not indispensable.

The merchant will tell us that he needs depth of water at the wharves, piers, or quays, that he may dispense with the awkward and expensive aid of lighters in loading and unloading cargoes. Yet the current must not run too violently against the wharves, so as to undermine them or render the moorings difficult, or create continual danger of collision. And the greater the line of wharf or quay frontage, possessing these qualifications, the more available is the port for his purposes ?

Boston Harbor once possessed these requisites in an eminent degree. The long circuit of wharves which fringed the margin of the city; the admirable channels, sweeping just past the ends of the wharves from the Back Bay, the South Bay, and the Mystic; the noble ship-channels, through the largest of which the largest frigate could stand boldly up to the city in an almost straight course, while two thirds of the shipping could be accommodated by the others; the magnificent and admirably sheltered roadsteads, inclosed by hilly islands; the excellent landing-places upon these islands; the fine bold headlands, beacons in themselves, to guide the pilot, or indeed to render his aid far less imperatively necessary, — all combined, within the memory of the present generation, to form a harbor of the first class.

To what influences are we to attribute the disastrous changes? We know some of the general laws, so far as regards the formation of channels. What are the other laws concerned, and what is their especial application?

Perhaps it may be well to consider one or two other general principles, before passing to their local effects.

And first, as to the formation of harbors in general. Omitting those which may be regarded as accidental nooks in rocky shores, where we have neither occasion nor opportunity for inquiry into causes or maintaining influences; also, such as owing to the absence or destruction of a maintaining force, are fast becoming useless to commerce, which is not an unfrequent case in regions where the gradual elevation or subsidence of the coast line is destroying the existing equilibrium, — we shall find that the harbors of alluvial shores belong to some one of three classes.

First, those which are not situated at the mouth of a river, but owe their existence to an interior basin, the scouring action of whose outflow exceeds that of the inflowing current sufficiently to create and maintain the channel. To this class belongs Portland.

Secondly, such as are simply the outlets of rivers, and are either without regular tides, or are so situated that the tidal action is not an important element in

their preservation. Harbors of this class are generally obstructed to some extent by a bar or shoal, occasioned by the subsidence or deposit of material which the water has borne along, until the enlarged facilities for outflow have so far diminished the velocity of the current that its transporting power is unequal to their further removal. To this class belongs Newburyport.

Thirdly, such as are situated at the mouths of rivers and are provided also with tidal reservoirs, thus owing their existence and maintenance to both forces; and it is manifest from what has been already stated that the joint action of the two forces may suffice to produce and to preserve an excellent harbor, even in cases where neither alone would have proved adequate. To this class belongs Boston, with its three rivers and three principal tidal basins.

And in any inquiry as to harbor changes, either for good or ill, originating either in natural or artificial disturbances of the existing equilibrium, we must keep in view both the joint and reciprocal action of these several producing and maintaining agencies.

Next, as to the forms of channels in their relation to the ranges of the tides and the velocity of the current. The laws which rule here are well set forth and explained in the fifth report of the Commissioners, published as City Document No. 35, of the present year.

It is well known that where a bay or inlet is favorably situated for the entrance of the tide-wave, and decreases in width from its mouth upwards, the tides are increased in range; in other words, that the amount of rise and fall becomes greater and greater as the tide travels up a wedge-shaped bay. This arises from the concentration, so to speak, both of the volume and the momentum of the inflowing water, occasioned by the convergence of the shores; and, reciprocally, by the reversed action at the outflow; and, conversely, when the tide-wave moves through a comparatively narrow inlet into an expanded basin it undergoes a "degradation of range," *i. e.* the extent of rise and fall is diminished as it spreads over the broader space within. "Tidal currents" are thus produced by the effort of the water to bring about an equilibrium between the basin and the sea; and it is found by observation, as a little reflection would lead us to anticipate, that their epochs or times of greatest intensity follow, not the times of high and low water, but the times of restored level between the basin and the ocean, which coincide nearly with the half tides.

We will state one more principle, and then leave theory in order to pass to the practical application of these dry (though watery) laws. And we cannot state it better than by quoting the language of the Commissioners: —

“ A contraction of a water-way augments the currents, and tends to increase the depth of the movable stratum, calling into action scouring forces near the bed of the channel. When a stream meets with a contraction, it is partially dammed up, so that an increase of head is caused, which not only augments the current upon the surface, midway between the two shores, but, by the increase of vertical pressure, causes particles far below to take the effort for the restoration of equilibrium. The greater proximity of the banks of the channel increases but very little the friction of particles moving along the central portion of the stream, so that their velocities are quickened nearly as much as they would be by an increase of head in an open bay.

“ We would not be understood to say that the increase of vertical pressure acts directly to increase the abrasion, but that it causes an increase of motion in the lower stratum, which scours away the channel-bed. It is often noticed that the water of a shallow stream, flowing into a deep lake or into the sea, continues to move on as a superficial current for a great distance ; but if after issuing from the mouth of the river it meets with a contraction of the channel, it at once communicates its motion to deeper strata. At such contractions the currents below the surface are often in excess of those on top. It seems to be the general rule that in a contraction the currents at a

central point, both as regards width and depth, have the greatest velocity.

“We see by this that it is a simple thing to call into action scouring forces by contracting a stream in a certain manner; but it has always been a difficult problem to dispose advantageously of the muds and sands which are removed from one point only to be accumulated at another.

“In the absence or scarcity of river waters, which tend to augment the ebb and check the flood-drift, the effects of irregularities in the widths of the water-ways in a tidal harbor are peculiarly disastrous. Sand is rolled along the bottom whenever the current exceeds 0.30 miles per hour; but so short a distance is travelled by a rolling grain of sand during one tide, that should the adverse current (that of the next six hours) be exactly opposed in direction, and equal in velocity to the preceding, the grain of sand will roll back to its original position, and no increase of depth will follow. This is simply a repetition of the doctrine we have so frequently announced before, that rolling material is moved in the direction of the resultant of the current forces of one tidal day precisely as if these forces acted simultaneously. If these forces are in equilibrium at any point there is not only no removal but usually an accumulation, since the sand is rolled up to this point from either side.”

To sum up these results, in the fewest convenient words, we may state as follows :—

That the range of the tide, *i. e.* its amount of rise and fall, is increased when, as in the Bay of Fundy, the tide-wave moves along a narrowing path, and is diminished when, as in the inlets of North Carolina, it traverses an expanding one ; the latter effect being greatest for an interior basin connected with the sea by a comparatively narrow inlet.

That the times and velocities of the tidal currents do not directly follow the epochs of high and low water, although of course indirectly depending upon them.

That these currents may undergo great changes as to their times and velocities, while the rate of the propagation of the tide-wave remains essentially the same.

That irregularities in a channel are in general detrimental, the contractions producing a scour which deepens the channel by the removal of material to be deposited just below the expansions ; these latter thus acting as shoaling agencies.

That in this way every decided contraction in a tidal channel tends to produce shoalings of the channel both above and below ; the one being created by the flood currents and the other by the ebb.

We will now leave the scientific principles, and in

our next article will show the application of some of them to the case of Boston Harbor,—its original formation, its present deterioration, and the possibilities of remedy.

NUMBER IV.

The outer harbor of Boston lies at the head of Massachusetts Bay, and may be regarded as bounded by the line, three miles in length, between the promontory of Nantasket and the extremity of Deer Island, itself once a promontory, though now insulated by the narrow channel known as Shirley Gut. Along this line now lie Lovell's, Gallop's, and George's Islands, which break the force of wind and wave; and in the same group with these was once a fourth, of which only the shoal called Nix's Mate is left. Outside of these were many more, only a few of which now remain, except in the uncomfortable shape of reefs and ledges. Among them may be mentioned the Three Brewsters, the two Calf Islands, Lighthouse Island, Green Island, and sundry others, now only known as this or that reef, or as somebody's ledge, or as something's or somebody's rocks. Between these rocks, or reefs, or ledges, are the approaches to the harbor. The dangers on the seaward side are easily avoided, thanks to the Coast Survey, by the seaman furnished with chart and log line.

And all the various approaches for shipping finally converge to three, along some one of which every laden vessel must pass in entering or leaving port. These are the main ship-channel, which passes between Lovell's Island on the northeast and Gallop's and George's on the southwest,—the united Broad Sound channels, where two or more approaches from the northeast unite in one to the north of Lovell's Island,—and the Back Way, which is on the south of George's.

The main ship-channel passes, between sundry rocks and shoals, through a passage called the Narrows, between the point of a spit on the one side, which extends southwest from the Great Brewster Island, and the Tower Rock on the other, a small submerged rock, dangerous to vessels drawing eighteen feet of water. The width of the channel here cannot much exceed one hundred and twenty-five yards, if indeed it reach that limit. This spit is entirely covered at high water, but at low water is seen as a narrow winding bar of a little more than a mile and a fifth long, forming a portion of the Great Brewster, and composed of loose and shifting materials. Between this point and Lovell's Island is the Black Rock Channel, which here unites with the main ship-channel.

The Commissioners reported in 1860 that the Great Brewster, which has been protected by a sea-wall

only at the end of the East Bluff, was so rapidly wearing away that, during the thirteen years since 1847, one hundred and fifty thousand square feet of its surface had disappeared from the hill; and that, whereas it originally measured one hundred and four feet in height and thirty-seven acres in area, thirty-two acres were now entirely gone, and very soon too little of the hill would be left to permit of grading upon an inclination suited to preserve its present height. Once the island on which this hill stood comprised also the Middle Brewster on the north and Lighthouse Island on the south. Now there is no connection, except in the form of shoals and a reef. The south shore of the island had washed away, during the same thirteen years, for an average distance of sixty-five or seventy feet; the total loss in that time amounting to about seventy-five thousand square feet. And not only this, but the encroachment had advanced to the base of the little hill on the south, which it was rapidly undermining. Thus, for want of the protection which a seawall would have given, was destroyed this bold and useful headland, only a shadow of which now survives, and from its destruction has grown that dangerous reef, Brewster Spit. This spit has risen till its summit is nearly dry at high water of low neap tides, and the extreme west and highest point has extended to the northwest two hundred and fifty feet since 1847.

A beacon then marked the extremity; but, when the "Spit Lighthouse" was built, this extremity had moved one hundred and fifty feet, encroaching to that amount upon Black Rock Channel. In 1860, the point had moved one hundred and seventy feet farther, and one half the lighthouse actually stood beyond the low-water limit. To-day the lighthouse rises not from the spit, but from the water.

Meantime the sea is washing away the Lighthouse Island also, and the United States Lighthouse Inspector, three years ago, called attention to the danger which was threatening Boston Light. Lovell's Island was found to have been washed away on both sides, the loss being one hundred and twenty feet on the south shore and nearly as much on the north; this, too, although its total width at this place was less than three hundred yards. But at the other end of the island, toward the Narrows, this island, too, was found to have encroached upon the channel.

In short, material had been transported from a point where it was desirable, and deposited where it was prejudicial by the action of strong ebb currents, of which a glance at the map will show the working, upon the general principles already explained. Wherever the sea-wall existed, not only has it protected the island from such abrasion, but it has arrested and accumulated large masses of sand and stones, which

are now acting to guard the island instead of swelling the volume of the materials which are actively building up reefs and shoals.

Passing to Gallop's Island, the low-water line had encroached upon the Narrows during the same thirteen years by fifty feet; and the same encroachment had gone on under water to an extent reducing the average soundings by five feet along the shore.

These are but illustrations of what has been and is going on in Boston Harbor. Of course we cannot even allude to all; but we have selected these because they bound the main channel in a critical place, and are encroaching upon it to a serious degree. So, too, the passage leading to the ship-channel from Nantasket Roads between George's and Gallop's islands. In their preliminary report the Commissioners stated that, whereas formerly a vessel coming up this way from Nantasket Roads saw a clear expanse of water through between Gallop's and Lovell's, the east end of one and the southwest extremity of the other have since increased so much that these two points appear to overlap, and that the increase of land has occasioned such changes in the line of deep water that a channel once nearly straight and comparatively easy is now tortuous and difficult. This change was due chiefly to the reckless removal of the heavier surface material from the east end of Gallop's Island for ballast, thus leaving the

lighter material a prey to the waves during storms and spring-tides. The light material thus removed was transported by the tide to the southeast part of the island, there building out a sort of spit, which encroaches seriously upon the deep water in an important place. Fortunately the counsel of the Commissioners to remove this island from private hands was promptly given and promptly followed, and this one danger was at last obviated, not too late to avert still more serious harm.

The second report of the Commission describes many cases of the destruction of headlands, analogous to and equally startling with those we have described. We will not dwell upon them, but will content ourselves with referring to their accounts of the havoc going on at Point Allerton, (where only about an acre and a half remain out of the forty-five which once formed Little Hill, and some fifteen acres of Great Hill are already destroyed,) at Nantasket, Long Island Head, Winthrop Head, and Deer Island.

Following the main channel inward, and traversing the spacious anchorage called President Roads, whose guarding hills and shores are sharing the common fate, we finally enter the inner harbor at the straits where the several channels unite to pass the narrow entrance between Castle and Governor's islands. There are, of course, water-ways between each of these islands and

the shore, which exert an important influence upon the currents, but the passage between the Castle and South Boston is not safe, at low water, for craft drawing over four feet; and the channel to the north of Governor's Island is so narrow, intricate, and contorted, as to be unsafe for ships under sail.

The principles already set forth show that, both above and below the narrow passage, we ought to expect shoals; and, just inside, we actually find the channel obstructed by the "Upper Middle" bar, while the "Lower Middle" divides the channel into two branches just outside the contraction. The positions are just such as to favor accumulation and deposit; yet it is probable that these shoals are in fact the remains of wasted islands, not removed much below the water surface, for the same reasons that would have promoted deposits had no islands existed,—yet, washed away above the surface by the agency of storms and the undermining power of the waves.

The Commissioners report that while both the strong ebb and flood currents ought to wash away, little by little, the clay by which the basis of the Upper Middle is formed, the tendency to accumulation in consequence of their insignificant *resultant* action in a tidal day has collected shells and other rolling materials, which, in the absence of sufficient power for their permanent removal, cover and protect the clay on which

they rest. The Lower Middle lies between the two different channels outside the straits, being west of the direct flood channel, and east of the channel into which the ebb is thrown by the interruption offered by Governor's Island.

Were the ebb current of the harbor to flow in one channel, instead of being divided into three, it would suffice to remove the Upper Middle. Indeed, were the outflow north of Governor's Island checked, which might be done without injury to that channel, in fact with benefit to it, this result would be obtained; if the outward current were sufficiently increased at any regularly recurring interval to wash away the deposit of rolling material, this bar would slowly disappear. But it is constantly increasing, and is a serious obstacle to the channel. The water on the Lower Middle is now so shallow and so quiet as actually to be covered with an abundant crop of sea-grass, — though situated in mid channel, — the flood-currents passing, as we have already said, on the one side, while the ebb passes on the other; the shoaling effect exerted upon the ebb by the expansion from out the straits being thus, in a measure, counteracted by the momentum of the stream.

Continuing to follow the main channel, and passing into the inner harbor, past the Upper Middle bar, we next find it obstructed by a knoll which projects into

it from Bird Island Shoal. Between East Boston and Governor's Island once stood Bird Island, larger than Governor's Island, on which now stands Fort Winthrop. Between this and Governor's Island, where a second-rate channel still exists, once flowed a vigorous tidal current, forming straits not unlike those between Governor's Island and the Castle; and between Bird Island and East Boston was still another excellent water-way, skirting the shore to the eastward of the Cunard Wharf, and rendering that a far better site for wharves than can be found south of Long Wharf. Access to these two ship-channels was supplied by a noble avenue, south of Apple Island.

Bird Island is now a shoal, bare at low tide; and to its destruction we owe many of the ills which have affected the inner harbor. The expansion of the inner harbor, occasioned by its destruction, produced degradation of tidal range. This, and the new fields opened for the passage of the tidal currents, so far diminished their scouring action that their former channels became places of deposit, and so far altered their direction that their action has lost much of its beneficial influence. The coarse sand has been wasted away, and gravel is the only material now left. The lost material has all been employed directly in the construction of shoals and spits, and indirectly in aiding the growth of still more. And the abrasion which

now goes on by extraordinary tides while the island is submerged, or by storms when the island is bare, chiefly results in the deposit of material along its margin. The portion above low-water mark will still continue to waste, and its component parts be employed in enlarging the area below that limit until it ceases to be exposed at any time of tide. For although the currents may as yet be such as to preclude any deposit of suspended material from forming an accumulation, the gravel and larger stones, moved by the action of extraordinary currents, will be transported laterally into deeper water. The spit or knoll however, to which we have referred, does not seem to be a product of this action. It was probably once an integral portion of the island, which the scouring action of the joint current of the Charles and Mystic, combined with the strong set of the ebb, has long since removed. The Commissioners are of opinion, that if this obstruction to the channel were dredged up, or what would be much cheaper, harrowed up, and suffered to wash away during the ebb, it would not reappear. And, although the Commissioners intimate nothing of the kind, we cannot avoid the conviction that a short sea-wall — built from a point north of the highest point of the island, sufficiently far to the east to check the scour of the flood tide — would, in connection with a second one, built in a proper curve

around the western point of the island, to turn part of the ebb scour into its former channel to the north, and to ward off the remainder from the southern shore, result in bringing about an accumulation upon this shoal, and even in furnishing a basis for the ultimate reclamation of the island, at the same time that the channels north and south would be improved.

The reclamation of Bird Island might even suffice, at some future day to re-establish a convenient ship-channel north of Governor's Island. For all along the southern bank of the island an accumulating tendency exists even now during flood-tide, and the accumulation is only removed by the action of the ebb.

The ship channel springs, as has already been explained, from the confluence of the streams which (taken in connection with tidal action) exert, or have exerted, a resultant scouring force outward, and from similar outward scouring forces arising from predominance of ebb currents over those of flood, owing to the forms of the shore lines, and especially those of the islands.

So far as the inner harbor is concerned we have the outflow of two rivers, the Charles and the Mystic; and of three tidal reservoirs,—the South Bay, whose scour created the deep water once existing between South Boston Bridge and Central Wharf; the Back

Bay, the existence of which rendered the mouth of Charles River an estuary; and the broad inlets known as Millpond and Miller's River, on either side of Somerville Point and between Charlestown and East Cambridge. The discharge of the last two gives its value to the wharf frontage of the North End, and to the wharves and docks of the Navy Yard, excepting, of course, that part which fronts on the Mystic.

Of these we next propose to speak.

NUMBER V.

The upper harbor of Boston owes its existence and maintenance, as has been already stated, to the outflow of two rivers, — the Charles and the Mystic; and of three tidal reservoirs, — the Back Bay, the Millpond, and the South Bay. In addition to these, the outer harbor is further supported by the outflow of the Neponset, the line of whose scour, after furnishing the means of access for vessels to the village of Neponset and to Commercial Point in Dorchester, passes to the westward of Thompson's Island, and contributes to the support both of the "Back Way" channel and of the channels leading outward from President Roads. The river has, however, no influence upon the upper harbor, except in so far as it obstructs the outflow between Castle Island and South Boston Point, — an influence which may, on the whole, be regarded as salutary.

The wharf line of Boston proper, from South Boston Bridge to Charlestown Bridge, extends along a curve of about two miles. Formerly about a mile more of wharves existed above South Boston Bridge,

and yet another between Warren and Cambridge Bridges. These are however at present of no commercial value, owing to interruptions inevitably occasioned by the bridges, which became a public necessity as the growth of the City progressed. Moreover there can be no reasonable doubt that the wharves now accessible to shipping are competent to furnish all requisite accommodations, provided that the docks do not fill up nor shoals form at their extremities. Should the docks fill up, the remedy is easily provided at the comparatively small expense of dredging. But if the channels of access tend to clog, the case is far otherwise, for man cannot long maintain the unequal struggle with nature ; and if natural forces cease to maintain the channels, commerce will seek other avenues. Our chief concern is with the influences which keep the channels open by preventing and removing deposit.

The material for deposit in our harbor is supplied from three sources, — the mud and sand brought from inland by the outflowing streams, the destruction of headlands and islands, and the sewerage of the City, — including all the waste and refuse which is thrown into the water. One or more of these sources is always actively supplying such material, and the flood tide brings all three into action. Wherever slack water occurs, at any time of tide, deposits take place rapidly ;

wherever a dock or an inlet affords a nook, whither the inflowing water may transport what it holds in suspension, while the departing tide draws its outflow from the surface chiefly, deposits will continually go on, although more slowly; wherever a current, bearing with it foreign but not floating matter, experiences a diminution of velocity,—either in consequence of an enlarged avenue for its flow or of a check to its momentum arising from some obstacle or some sudden alteration of its direction,—the subsidence of the suspended material is equally inevitable. The only possible preventive of permanent shallowing in such situations must be sought in an outward scour, adequate to remove all these deposits; and this scouring force is dependent, as we have seen, upon the excess of the momentum of the outflowing current over that of the inflowing. Hence a bridge, built on piles only, is often adequate to the destruction of a channel, and almost invariably produces injury. If, however, instead of piles, its base is partly formed by an embankment or wall, the first effect must be to cause a diminution in the depth of water both above and below those places where the bridge acts as a dam, restricting the channel to such positions as permit the direct passage of the current; and if the dam thus formed crosses tide water, the degradation of range within the basin which it forms acts to diminish the force of both

inward and outward currents, — thus tending to fill up the basin and the channel through which the water enters and leaves it.

The current which brings the combined outflows of the Back Bay, the Charles River, and the Millpond, through the straits between Charlestown and Boston, there meets the ebb from the Mystic, which forces it back from the East Boston shore, — deflecting its direction sufficiently to make its channel skirt the wharf line nearly as far as T Wharf; although decided deposits along this line have been indicated by each survey since 1835. The Mystic outflow, reinforced a little by Chelsea Creek, is pressed in like manner against the East Boston side, and the two currents then pass together outwards, as explained in our fourth article. The Fort Point Channel, issuing from the South Bay, gives access to the tier of wharves from Long Wharf southward, and separates them from the South Boston Flats, — the northerly apex of which is nearly opposite the dock between Central and India wharves; although no part, north of Rowe's Wharf, is absolutely exposed at low water. Were this channel to fill up, the line of flats would extend from Long Wharf to South Boston Point; and the other outward currents would merely suffice to give this line a concave form.

Let us now consider the waters which find their

outlet between Boston and Charlestown from the estuary of Charles River, consisting of the stream of the river itself, and the outflow of the two tidal reservoirs. Here we find that the encroachments have been absolutely enormous. Some, like the filling in of the new lands, from whose reclamation we hope for much benefit to Boston, are in themselves so great public gains that they may well offset considerable detriment; and the detriment may indeed be left out of consideration when, as in this case, a great portion of it had long since been inflicted by the construction of the Milldam. So, too, the multiplication of bridges in the most critical positions of the channel must be borne as a necessity. Even the encroachments on the westerly side of the Milldam, which usurp still valuable water area, and have the additional disadvantage of destroying the beauty of what would otherwise soon have become one of the most beautiful avenues in the world, are palliated by the consideration that flats had already formed there in the place where many of our citizens once knew four navigable channels.

But what shall we say of the needless encroachments by the railroads between Warren and Cragie's Bridges? For the mere sake of the convenience of more land, an enormous amount of water area has been here covered over. Without considering the amount of solid filling, the forest of piles here driven

by the four railroad companies, for purposes not demanded by the public need, has sufficed materially to diminish the momentum of the current, and has unquestionably produced a great degradation of tidal range in the basin once known as the Inner Harbor. But worse than this, two huge causeways have been thrown from East Cambridge in curved lines toward the city and filled in with earth, thus acting as complete dams. The recent conversion of Prison Point Bridge into a solid causeway, actually damming up the whole of the second tidal reservoir, cannot be too deeply lamented. No water communication now exists between the sea and the waters lying between East Cambridge and Charlestown, except at a single drawbridge. A tidal reservoir of great value has thus been converted into a mere basin, the rise and fall of whose tides is much less than in the harbor, which is continually growing shoaler; and the capacity of which is, moreover, continually suffering diminution by fillings in with earth.

Passing on to Cragie's Bridge, we here find equally serious invasions of the water-way by structures pushed to the actual verge of the channel. These, like those last mentioned and like the very injurious and extensive fillings in at the Cambridgeport end of the Cambridge Bridge, ought never to have been permitted by the Legislature. For the sake of present pecuniary

emolument, it would appear that the future welfare of the City has been sacrificed to an extent which could not be compensated by manifold the total gains of the railroad company and of the individuals concerned.

In all these serious encroachments there is a fourth element of harm to which we have not especially alluded, although it may be readily inferred by those who have perused our summary of general principles in former articles. Not merely have the two tidal reservoirs been essentially destroyed, — one of them without any corresponding public gain, — and also the water area of the estuary greatly diminished; not only, in addition, has the flow of the main currents been deliberately obstructed by permanent solid structures of earth and stone, built out across the directions of their flow; nor is it alone, beside these, that so large a mass of open piling has been constructed in the straits that the momentum of the water is almost entirely destroyed, — but over and above all these inexpressible injuries, the currents of the ebb and flood are so differently affected by these artificial structures, that their channels follow different paths; and have become so complicated, through continual deflection by obstacles at different angles with their directions, that a new train of peculiar and serious evils has been originated.

The reader may naturally inquire, "What is to be done?" "How can all this evil be remedied?" The answer is a sad one. It cannot be remedied. And, even were private interests made subordinate to public ones, and present local short-lived gain subordinated to the permanent welfare of the City, comparatively little of the damage could be repaired by the expenditure of a hundred-fold those outlays which have produced it. Legislatures and lobbyists must bear a large share of the heavy responsibility. But this, at least, can be done: A public sentiment can be and ought to be aroused which should make it disreputable for any man or body of men to commit further encroachment, and in any legislator to sanction further invasion of the water area around Boston, until some competent commission of scientific men has placed on record some certificate that the injuries already inflicted upon the harbor will not thereby be augmented. And, if their certificate to this effect be accompanied with any proviso, the uttermost fulfilment of such proviso should be enforced with a determination and tenacity greater than Shylock's —

"If every ducat in six thousand ducats
Were in six parts, and every part a ducat,
I would not draw them; I would have my bond."

It may well be, indeed it certainly is the case, that

there are places where the building out of the shore, and indeed the redemption of flats, may be harmless,—provided that for every step of the encroachment a corresponding enlargement of the water capacity at some other point could be insured. There are many places where, as in the case of Bird Island, already considered, an actual filling in may be a gain. But let us make sure that no more encroachments be permitted, unless duly certified to be innocuous; and unless the execution of every condition insuring their harmlessness be rigorously extorted. Only by the overpowering force of public opinion can the course of destruction be stayed, so long as men can be found who seek private gain at the expense of an unutterably greater public loss.

NUMBER VI.

There are many important topics connected with the physical defence and maintenance of Boston Harbor, to which we would gladly advert. But we fear to trespass too much upon the reader's patience, lest he cease to be a reader at all. If we can but impress those, whose judgment guides the public counsels and shapes the public opinion, with a sense of the irretrievable injuries already inflicted; convince them that these injuries are due to artificial influences; show them how certain ones have been brought about; how some can be remedied, some obviated, and some prevented,—our object will have been attained. And whether this desirable object be or be not attained, we desire also, as a Boston boy, to express our sense of the services rendered by our Mayor in originating, encouraging, and aiding the Harbor Commission; to the Commissioners for their laborious, gratuitous, and invaluable researches; and to the assiduous and skilful engineers and hydrographers, through whose personal exertions the facts have been collected and the results obtained upon

which all our conclusions must necessarily depend. Among these, Mr. Henry Mitchell, of the United States Coast Survey, and Mr. A. Boschke, appear to have been especially prominent. In their reports, the Commissioners pay high compliments to both of these gentlemen, and state that the materials for their inquiry into the present regimen of the harbor "are chiefly furnished us through the labors and researches of our accomplished colaborer, Mr. Mitchell."

Among those subjects which furnish a wide and interesting field for inquiry, connected with the preservation or reclamation of the harbor, are the laws which govern the flow of Mystic Pond, and the tidal ranges and currents of the Mystic River. The discussion of these, in connection with the Charlestown Aqueduct, forms the topic of the third and most extended report which the Commission has yet presented; and has brought to light many new and extremely instructive facts relative to the nature of its operation as a tidal reservoir; the principles which should govern the construction of sea-walls; their action in promoting accumulations at certain points by the destruction of momentum in waters which are transporting material for deposit, or by the deflection of a current into a wider or an expanding path; their influence in defending head-

lands and island shores; their power of creating scour in special channels, —all are of great importance in their applications to the Outer Harbor. The distribution and deposit of the sewerage of a great city is always an important question, and is especially so in our own harbor on account of its peculiar conformation. The special effects of the dams, which have been or may be constructed across important water-ways; the influences which the Mystic and the Neponset respectively exert upon the inner and outer harbors; the nature of that action by which the outflowing currents of the Charles and the Mystic each tend to push back the other against the opposite shore; the differences in the epochs of the currents which flow from the different outlets in the harbor, and give a totally distinct character to the lines of deposit and of scour from that which would result from simultaneous epochs in their different currents, —all these, and many others like them, offer strong temptations to dwell for a while on the interesting questions which they present. But our present purpose is a limited one, and we will therefore confine ourselves to the consideration of the Fort Point Channel and the South Boston Flats.

The South Bay was originally a tidal reservoir of considerable magnitude. Less than half a cen-

tury ago, the high spring-tides submerged Boston Neck, flowing entirely across Washington Street, (then the only avenue,) and rendering the City an island. Scarcely thirty years have passed since the "South Cove" was filled in, embracing most of the territory east of Harrison Avenue, south of Beach Street, and north of the Dover Street Bridge. Much of the area now occupied by land on the South Boston shore is also made-land, as is a considerable tract at the South End; so that it is probably within bounds to say that one third of the area of this basin has been filled up, and at least one quarter of the remaining water capacity destroyed by deposits,—making an actual loss of about one half the cubical contents of the basin. No streams of any magnitude empty into the South Bay; the most important being the brook which rises a little south of Grove Hall, and forms the boundary between Roxbury and Dorchester.

The South Bay thus depends upon the tide alone for its supply of water; and the tidal currents have here also been obstructed to a very great extent by solid embankments, which have been pushed across the water-way, leaving only a sufficient width at the drawbridge to permit the passage of vessels. The tidal current, thus reduced in volume by the diminution of the basin, and in intensity by the degradation

of range within the basin whose entrance is thus contracted, is deprived also of its momentum by the obstructions offered by the several embankments of four bridges, and flows into the harbor with not more than a fifth part of the scouring force which it possessed thirty years ago. After reaching the foot of Summer Street it finds an outlet, and while its momentum yet suffices to carry part of the stream as far as the end of Long Wharf, a very considerable portion of the water finds its way out across the flats, where its diminished velocity occasions additional deposits; so that these flats are growing continually shoaler and wider.

The two comparative maps, prepared by the Commission, and showing the changes in the harbor between 1835 and 1847, and between 1847 and 1861, respectively, illustrate these facts with great clearness.

During the former of these periods, the natural shore on the East Boston side — which at first presented a concave front to the impinging waters of Charles River, and thus brought the tidal currents of the Mystic during ebb into disadvantageous relations with those from Charles River — was filled out by solid wharves to the convex curve of the “Commissioners’ Line;” thus securing for this region an excellent channel-way, and forcing the

Charles River scour along the Boston shore as far as T Wharf, to which the opposite currents from Fort Point Channel also extended, though not at simultaneous epochs. Hence the redemption of this land at East Boston exerted a beneficial influence on both shores, and a scouring force was brought into play, which deepened the stream along the front of the wharves, especially from Commercial to T Wharf, and abraded the point of the South Boston Flats, deepening the water very essentially. Unhappily this is the only gain to be recorded, and was offset by most calamitous encroachments, both by bridges and by too great extension of wharves at the North End. And although the improved wharf-line at East Boston deepened the water at Lewis's Wharf, and at the extremity of South Boston Flats, — all the rest of the inner harbor grew shallower inside a line between the wharf at the foot of E Street, in South Boston, and the Eastern Railroad Wharf, in East Boston. The South Boston Flats grew shoaler, and large deposits took place in the Fort Point Channel. The solid filling in South Boston, consisting of a "wharf" sixteen hundred feet long where Boston Street and Granite Street now are, converted the Fort Point Channel for this distance into a canal, through which the whole of the current from the South

Bay flowed, until it found its outlet near where the fourth bridge now is. The canal itself was of course deepened thereby; but the channel shoaled to a more than corresponding extent a little beyond the place where the ebb first found opportunity for dispersion, — namely, from a point just beyond the extremity of this structure, as far northward and eastward as the currents of the Charles and Mystic would permit, and along all the docks and wharves excepting three as far as Rowe's Wharf.

During the second interval, viz: from 1847 to 1861, there seems to have been no agency of any sort at work to exert a beneficial influence on the harbor; unless perhaps that at East Boston, already referred to, may have continued to some degree on the East Boston shore, north of the Cunard Wharf. All the benefit on the Boston side was more than lost again. Apart from the encroachments of every kind, already described, which had diminished the current from the Charles, — the “Wharf” in South Boston was extended one thousand two hundred feet farther, making it twenty-eight hundred feet long. Inside of the Central Railroad Bridge, the canal thus inclosed has of course become deeper, and at its extremity has been formed a shoal. But its ebb current being now confined for more than half a mile to a nearly straight line, has acquired a considerable momentum. The Fort Point

Channel proper is thus much lengthened, and is, indeed, deepened beyond this first shoal; but it has been pushed away from the shore, and its stream encountering the current from the Charles and Mystic, neutralizes their force sufficiently to have formed a second and very large shoal which reaches to the upper Middle Bar,—its base extending from Lewis's to India Wharf. During the interval between the second and the third or present survey, every dock but one, and the end of every wharf in Boston, north of Battery Wharf, has shoaled; and this shoaling is going on to-day. The extension of the E Street Wharf, and the construction of the wharves at the Grand Junction depot, have moved the limit within which the deposits are greatest outward to a line drawn from the present extremity of the former, to the most easterly of the latter.

In short, we have arrived at this unpalatable necessity, that we must sacrifice a good deal of what remains, in order to make the rest available. The result at which the Commissioners seem to have arrived appears to be,—that our best measure now is to surrender all the water-area covering the South Boston Flats, which have already grown so shoal as to be worth comparatively little for purposes of navigation, and by filling them in up to a line including Castle Island, and thus cutting off the water-way between that

and Dorchester Point, so to direct what elements of harbor maintenance are left that they shall keep the ship-channel open. To make the Fort Point Channel useful, it must now be converted into a canal for a yet greater distance, and must be dammed in as far as India Wharf. In case it then meets the streams from the Charles and Mystic in such a way that their currents oppose each other, new shoals will arise at the point of collision, and deposits off Long and Commercial wharves will still continue to form. Its current must consequently be guided into the main channel, along a path which shall curve as little and as gently as may be, and yet bring the ebb streams together, at the smallest possible angle. This implies an extension of Central and India wharves, and, perhaps, of Long Wharf also.

The actual cautery is not an agreeable application. But Bostonians have brought it upon themselves, and although this may not sweeten the remedy, it must lead us to bear it with the greatest philosophy in our power. We cannot conceal it from ourselves that the grand harbor, of which we were so proud, is gone ; nor are we ignorant of the cause. We must now do our best that a second-class harbor shall not degenerate into a third-class harbor. Those who have rejoiced over the real estate which they have made for themselves and their posterity are too much like those

rulers who have thought they were growing richer by the issue of paper money. If they are not on the alert, these expensive encroachments will count but little for the advantage of those heirs for whom they have been willing to sacrifice so much. The rent of palatial warehouses in Cranberry Centre would not be enormous.

Now, if South Boston Flats are to be filled in, — and filled in they will sooner or later have to be, either by the accumulation up to tide-mark through natural agencies, or else through human handiwork, — there certainly ought to be a compensation somewhere; and unless the deterioration of our harbor is yet to continue, there must be found a new place somewhere for a cubic foot of water to offset every cubic foot of water-capacity that is destroyed. And a true economy will demand, in addition, that whatever reservoirs are made or deepened or widened shall be so devised and constructed that the forces of nature brought into play shall tend to their maintenance, and not to their destruction.

In what we have said in these discussions of the influences which have brought about the injury, and are fast bringing about the destruction of Boston Harbor, pecuniary interests must be involved to no small extent. Individuals, corporations, speculators, capitalists are concerned for or against this or that measure,

on every side and in every conceivable way. The ground is delicate wherever we touch it, since powerful interests are affected at every step, which will earnestly and obstinately maintain such doctrines as shall appear to inure to their advantage. But we have endeavored to write as a lover of our beloved city,—having her interests in view, and hers only. And in the fullest confidence that the candid reader will bear witness to the absence of all personal feeling, of all tendency to denunciation, of all advocacy of pet schemes,—in short, of all motive other than the manifest and avowed one,—we will, in closing, only express the fervent hope that what we have said may lead to some appreciation of the true state of affairs,—perhaps, indeed, stimulate to some judicious exertion; and that part of what we have refrained from saying may still be inferred from the facts and principles developed.

P. S. — Since the preceding articles were written, the author has obtained through Professor Bache, of the Harbor Commission, the following memorandum which Mr. Boschke has had the goodness to prepare, showing some of the ravages during the period since the survey. In the coming winter they will probably be, at least, equally serious.

It may not be amiss in this connection to call attention to the fact, that an appropriation towards the protection of Boston Harbor, which passed the House of Representatives, February 28, 1863, in the Civil Appropriation Bill, was lost in the Senate, apparently without much opposition.

CAMBRIDGE, *December*, 1863.

MEMORANDUM.

Mr. A. Boschke's resurvey of the Islands in the Outer Harbor last summer, show that since 1860 the Great Brewster has suffered from want of protection by sea-walls. The southerly headland, a bluff of about forty-five feet high, has been reduced by seventy-five feet in its entire length. The high bluff facing northwest has suffered an average slide of from twenty to thirty feet. This bluff is at its greatest elevation over one hundred feet high. A sea-wall on this side of the Brewster is also essential, but of equally great

importance is the grading of the bluff and seeding down in grass, and near its base planting of bushes.

The other Islands have wasted, on an average, by one to two feet per year, with occasionally a larger slide of from five to ten feet for twenty to forty feet in length.

On Deer Island the sea-wall requires repairs. In four places, measuring an aggregate of four hundred to five hundred feet, the filling has washed out nearly to the foundation, and the deck-stones have fallen in. It is evident that surface-water has been directed against these places by gulleys in the bluff. Grading the bluff, and seeding down, would prevent similar accidents.

L. H. S.





LIBRARY OF CONGRESS



0 021 624 863 6